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ELECTROSTATIC PRECIPITATION VS. HEPA FILTRATION IN
REDUCTION OF AIRBORNE MICROORGANISMS IN DENTAL
OPERATING ROOMS

by

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ABSTRACT

The purpose of this study was to measure the ability of electrostatic precipitation (ESP) to reduce the number of airborne microorganisms in two DOR's of 1,800 and 850 ft³ size, and to compare the results with those obtained with a high efficiency particulate air (HEPA) filter module. The effect of air cleaning by either one or two ESP units (air flow rate of 175 cfm each) or a floor model HEPA module (800 cfm) was studied. The effectiveness of the units was tested using a Reyniers slit sampler to measure the reduction of microbial air concentrations.

The reduction in number of microorganisms in the air of empty DOR's was found to be influenced by the ratio of room size to unit capacity. At a ratio of 2:1 the air cleaning effectiveness of the ESP and HEPA filter units was the same. A mean concentration of 5.0 VP/ft³ was significantly reduced to 1.0 to 2.0 VP/ft³ by either the ESP or the HEPA filter units.

Peak microbial air concentrations in DOR's where dental procedures were being performed were reduced by air cleaners at a higher rate than that found with no cleaners.

INTRODUCTION

In dental operating rooms (DOR's) many sources act to increase the concentration of microorganisms in the air.¹⁻⁵ It is not known, however, whether the presence of these microorganisms constitutes a danger to health. Until epidemiologic studies can determine a precise relationship between numbers and types of microorganisms in the air of DOR's and the incidence of disease, it can only be assumed that a reduction in microbial numbers is followed by a reduction in cross infection.

Microbial concentrations in DOR's can be effectively reduced by using a high efficiency particulate air (HEPA) filter module.⁶ Under experimental conditions⁷ it had been shown that electrostatic precipitation (ESP) is as effective as HEPA filtration in reducing the number of airborne bacteria, but this finding had never been tested in a DOR. The purpose of this study was to measure the ability of ESP units to reduce the number of airborne microorganisms in a dental operatory, and to compare these results with those obtained with a HEPA filter module.

MATERIALS AND METHODS

Two DOR's with capacities of 1,800 and 850 cubic feet were used. Dental activity in these rooms consisted only of cleaning and scaling of teeth. These rooms were used under normal conditions during which windows and doors were kept closed and ventilation was through heating ducts. Two categories of activity were established for comparison and evaluation: (1) Empty room (no activity and no persons in the DOR); (2) dental procedures (activity included the performance of dental procedures on a patient).

Air cleaning procedures were carried out by using either one or two portable ESP units* each of which had an air flow rate capable of cleaning 175 cubic feet of air per minute (cfm), or by using a floor model 800 cfm blower-filter module† containing a HEPA filter. The HEPA filtering module in the 1,800 ft³ DOR was placed against a wall 6 feet in front of the patient; in the 850 ft³ DOR it was placed against a wall 3 feet behind the patient. The ESP units, depending on the number used, were placed in one or two corners of the rooms either 3 or 8 feet in front of the patient.

Samplings were taken for 2 consecutive hours each morning during which routine dental procedures were performed. Air cleaning was carried out during one of these hours. The concentration of viable particles (VP) was determined with a Reyniers slit sampler‡ at an air

The opinions or assertions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

*Model F38, Honeywell, Inc., Minneapolis, Minn.

†Model No. 43X, Agnew-Higgins Inc., Garden Grove, Calif.

‡Reyniers Sampler, Model FD-100, Reyniers and Son, Chicago, Ill.

flow rate of 1 cfm. The orifice of the sampler was 3 feet above the floor--10 feet from the patient's mouth in the larger DOR and 3 feet away in the smaller room.

The culture medium used in the Reyniers sampler was 5% whole defibrinated rabbit blood in trypticase soy agar* contained in plastic dishes.[†] After sampling, the dishes were incubated at 37° C for 24 hours and the colonies were counted in reflected light. Each colony was assumed to represent a single VP. The microbial concentration was reported as viable particles per cubic foot of air (VP/ft³). Predominant types of microorganisms recovered during sampling procedures were identified generally by morphological characteristics.

Peak viable particle (PVP) concentrations during dental procedures were determined in samplings that revealed a momentary shower of colonies with counts at least five times higher than normal (25 VP/ft³). The airborne microbial concentration for the next 15 minutes was measured separately for the respective air cleaners, and the results were then compared with those obtained without cleaning devices.

RESULTS

Predominant types of microorganisms recovered during sampling procedures were streptococci (all three hemolytic types), staphylococci, micrococci, flavobacteria, pseudomonas, and other gram-negative bacilli.

The effect of air cleaning on microbial concentrations in empty DOR's is shown in Table 1. A concentration of 5.0 VP/ft³ was normally found in these rooms. This concentration was decreased significantly by either the ESP or the HEPA units. It is known that the ratio of room size to flow rate has an influence on the amount of reduction of microorganisms in the air.⁵ It is evident, however, that at the same ratio (approximately 2:1) the reduced microbial concentration obtained with the two ESP units (1.1 VP/ft³) was significantly no different than with the HEPA filter unit (1.7 VP/ft³). The larger ratios (4.8:1 or 5.1:1) showed considerably less effectiveness.

Table 2 shows the effect of air cleaners on peak microbial concentrations in the air during dental procedures. The peak microbial concentrations with each of the cleaners was about the same (approximately 80 VP/ft³). Even without air cleaning, a 50% decrease in airborne PVP occurred in 15 minutes. The greatest effect of the cleaners was noted during the first 10 minutes, when PVP concentrations were reduced about two times faster with air cleaners than with none. The difference between the rate of reduction of peak concentrations with the two ESP units vs. the HEPA filter unit was not significant.

DISCUSSION

It is evident that air cleaning devices accelerate a reduction of airborne microorganisms in DOR's. Findings with the HEPA filter unit confirmed previous reports.⁶ Results with electrostatic precipitation showed that it can be as effective as HEPA filtration.

*Baltimore Biological Laboratories, Inc., Baltimore, Md.

†Catalog No. 1013, Falcon Plastics, Los Angeles, Calif.

Table 1.--Effect of air cleaners on microbial concentrations in empty DOR's

Air cleaner* (No. units)	Ratio of Room size†/ Unit flow rate	No. of trials	Microbial concentration VP/ft ³
None	---	37	5.0 ± 3.8
HEPA (1)	1:1	6	0.9 ± 0.4†
	2.2:1	19	1.7 ± 0.9†
ESP (2)	2.4:1	5	1.1 ± 0.5†
	5.1:1	30	3.2 ± 2.5§
ESP (1)	4.8:1	5	2.8 ± 1.0†

*HEPA, High efficiency particulate air filter module; ESP, Electrostatic precipitator unit.

†Room size, 850 ft³ or 1,800 ft³.

‡Significant decrease by "t" test ($P < .01$).

§Borderline significance ($P = 0.03$).

Table 2.--Effect of air cleaners on peak air concentrations during dental procedures

Air cleaner* (No. units)	No. of trials	Peak microbial concentration† VP/ft ³	Reduction in PVP/ft ³ (%)		
			5 min	10 min	15 min
None	6	63 ± 54	22 ± 18	33 ± 21	50 ± 24
HEPA (1)	9	89 ± 60	52 ± 20	70 ± 19	86 ± 12
ESP (2)	4	77 ± 48	46 ± 23	81 ± 7	90 ± 3
Overall		78 ± 54			

*HEPA, High efficiency particulate air filter module; ESP, Electrostatic precipitator unit.

†Room size, 1,800 ft³.

In an empty DOR where the ratio of room size to unit flow rate was 2:1, there was no practical difference between results with the ESP and HEPA filter units. Similar findings have been reported using an experimental room.⁷

The ratio of room size to capacity of an air cleaning unit should be considered when selecting an air cleaner. In small rooms of 500 to 1,000 ft³ size, one or two ESP units could obviously be as effective as one HEPA unit. In larger rooms, however, the HEPA unit would probably be more practical.

The wide variation in microbial air concentrations noted during dental procedures made it difficult to evaluate either the ESP units or the HEPA filter unit under these conditions. Where the rate of reduction of PVP concentration was used as a criterion, no significant difference was found between the ESP and HEPA units. Because these studies were carried out in an 1,800 ft³ room, the respective room size/unit flow ratios were 5.1:1 and 2.2:1. It appears that during a period of rapid fallout of high concentrations of microorganisms the unit flow rate may not be as critical as it is with lower concentrations of microorganisms. A greater number of tests than those performed in this study would be required to establish this.

SUMMARY

1. The effectiveness of electrostatic precipitators (ESP) and high efficiency particulate air (HEPA) filters in reducing microbial air concentrations was compared in two dental operating rooms.
2. The concentration in the air of empty DOR's, which was usually 5.0 VP/ft³, was reduced to 1.0 to 2.0 VP/ft³ by either the ESP or HEPA filter units.
3. Peak microbial concentrations of approximately 30 VP/ft³ obtained during some dental procedures were reduced by either ESP or HEPA filter units faster than with no cleaners.
4. A factor in the selection of an air cleaning device is the ratio of room size to unit flow rate; this ratio should be no greater than 2:1.

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